SATELLITE IMAGERY OF OCEANOGRAPHIC FEATURES

OVERVIEW

Identify oceanographic imagery features seen in satellite

OUTLINE

Oceanic fronts

Eddies

Upwelling

Internal waves

Sea ice

SATELLITE IMAGERY OF OCEANOGRAPHIC FEATURES

Using satellite imagery to detect oceanographic frontal boundaries, eddies, etc., has made our job as Aerographer’s Mates in the world of ASW easier than in the past. Many features were missed in the past because of the lack of reports or poor analyis, and many sonar-related problems could not be adequately explained based on past charts. Observing the oceans through the eyes of satellites provides for far greater coverage of oceanic features and greater accuracy in the location and movement of these features.

Learning Objective:

Differentiate between permanent and transient oceanic fronts, and recognize the differences that

OCEANIC FRONTS

The mean surface positions of the major oceanic frontal systems of the world are depicted in figure 3-1-1. You will note that most of the fronts are located along the boundaries of surface oceanic currents. These fronts are termed "permanent", because they are observed during all seasons in the same general geo-graphic location. These fronts do not move significantly from their mean position. Oceanic fronts that are comparatively short lived and show considerable variation in location are termed "transient". Such fronts may exist from a few days to several months. They are primarily the result of seasonal water changes, regional upwelling, open-sea convergence and divergences, pronounced surface heating or cooling, or river runoff.

Oceanic fronts separate water masses of different densities, and since the density of seawater is a function of temperature and salinity, there are thermal (temperature) fronts and haline (salinity) fronts. Oceanic fronts are found in the upper layers of the oceans in areas of pronounced horizontal temperature and/or salinity gradients. One such area is off the east coast of the United States where the Gulf Stream interacts with the much cooler coastal waters and the cold Labrador current.

The Gulf Stream front is located in the region of the sharply defined thermal gradient that exists between the Gulf Stream water and the coastal waters. A typical vertical cross section of temperature across the Gulf Stream during spring is shown in figure 3-1-2. Note the sharp vertical temperature gradient on the coastal side of the Gulf Stream. The persistence of this gradient has given rise to the term *north wall* to describe this portion of the Gulf Stream. The north wall, as revealed by the temperature contrasts in satellite imagery, delineates the surface synoptic location of the Gulf Stream frontal system. In addition to the temperature and/or salinity differences across oceanic fronts, there may be differences in water color, wave height, and current velocity.

Oceanic fronts and currents can be monitored in infrared satellite imagery. Temperature differences across the frontal zones produce distinct gray shade patterns which reveal the frontal systems, including meanders and eddies. Regions of upwelling, river runoff, and current boundaries can also be distinguished in imagery through gray shade differences. Figure 3-1-3, an infrared picture taken in March 1988, shows the shades of gray associated with the thermal contrasts along the eastern coast of the United States.

Distinguishing oceanic features in visual imagery is far more difficult than it is in infrared imagery. It is possible to distinguish a front that lies in an area of sunglint if the difference in sea states across the front is strong enough to produce light and dark shading in the frontal zone. It is important to recognize that the oceanic frontal features seen in satellite imagery are those of the oceans’ upper layers only. Just as meteorological fronts extend upward into the atmosphere, oceanic fronts extend downward into the ocean. For example, fronts associated with major currents often extend to considerable depth (Gulf Stream 3,300 ft; Kuroshio 2,300 ft), while fronts formed by surface heating and cooling or river runoff are quite shallow (165 ft, or less). Below the surface across these fronts, there may be differences in light transmission, dissolved chemicals, biological population, and sound velocity propagation. The latter two are very important in sonar applications.

Learning Objective:

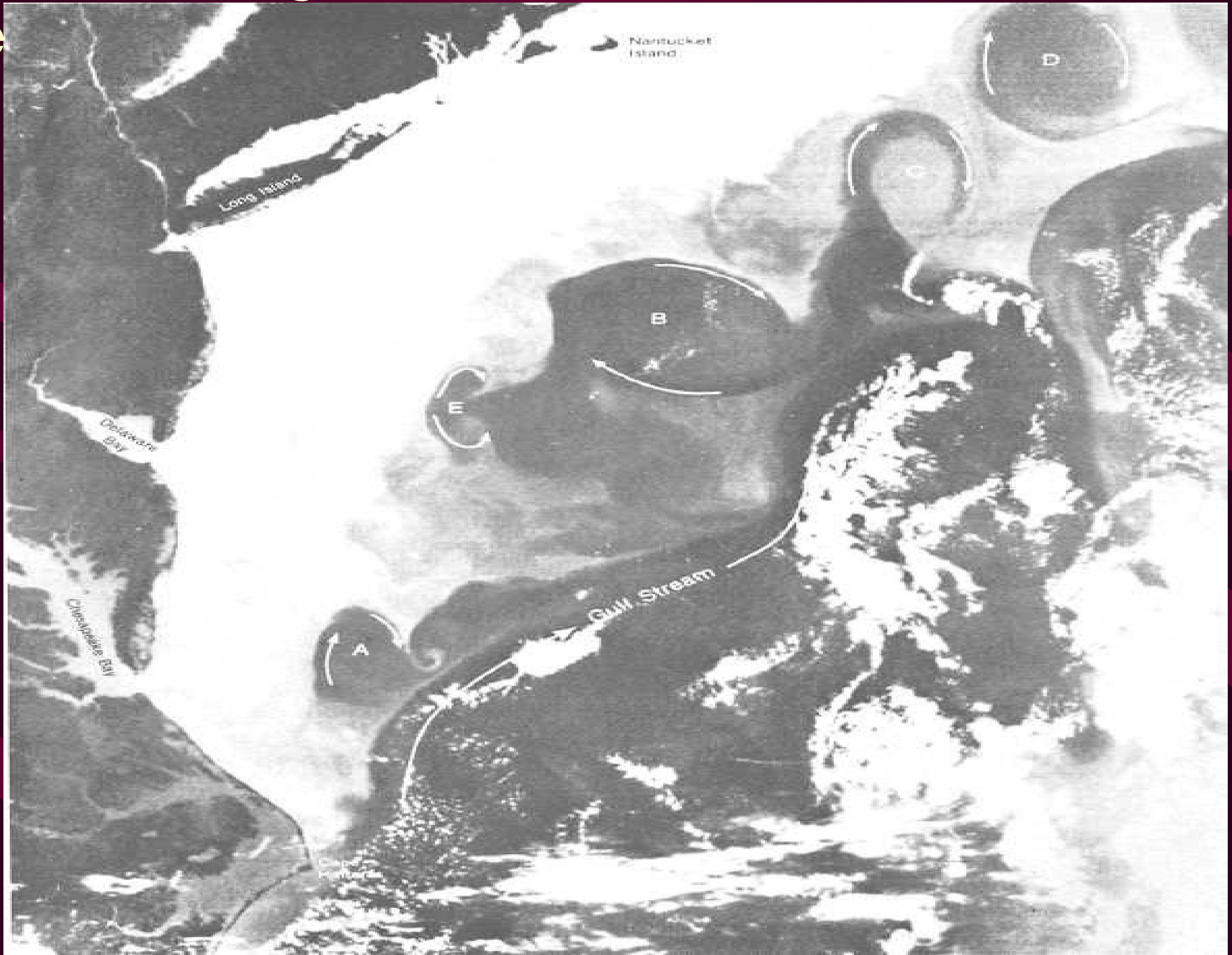
Identify the two types of oceanic eddies and the type of satellite imagery used to locate and

EDDIES

Oceanic eddies are distinct, closed cyclonic or anticyclonic circulations. Cyclonic eddies are generally cold core, while anticyclonic eddies are generally warm core. But if the temperature of the water increases as you move outward from the center of an eddy, the eddy is cold cored (coldest temperature at the center), regardless of the circulation.

Eddies are formed in several different ways. They can develop when a meander in a major ocean current becomes very large and gets cut off from the main current. Such formations are similar to the cut-off highs and lows that occur in the primary circulation patterns found in the atmosphere. These eddies have diameters that range between tens of miles to hundreds of miles and, like the currents that form them, their circulations are strongest near the surface. Eddies are also produced by the deflection and/or channeling of an ocean current by the shape of the coastline and the topography of the ocean bottom. Small eddies (tens of miles in diameter)have also been observed to form from the intrusion of one water into another.

The surface-temperature patterns of oceanic eddies are visible in infrared satellite imagery. The temperature differences across eddies produce gray-shade differences. The figure below shows eddies formed by meande



Cold eddies are often partially encircled by a convective cloud line at their edge, while convective clouds may form directly over warm eddies.

Cold eddies act as an atmospheric stabilizer by cooling the air directly overhead, thereby slowing the movement of stronger winds aloft toward the surface. Thus, there is a tendency for the seas in cold eddies, and cold water in general, to be less rough than the surrounding warmer waters.

Eddies are also used tactically by submarines because of the sound propagation differences that exist inside and outside these circulations.

Learning Objective:
Identify thermal patterns created by upwelling.

UPWELLING

Upwelling in a body of water is a process by which subsurface water rises toward the surface. Since water temperature generally decreases with depth, the upwelled water is colder than the surface water it replaces. Thus, sea-surface temperatures are characteristically lower in areas of upwelling. Infrared imagery provides information on the position and strength of the surface thermal gradients associated with upwelled water. The gray-shade patterns may appear as bands of lighter gray shades (colder temperatures) extending along coastlines. The pattern may also show plumes of cold water or cold eddies intruding into the warmer waters further offshore. See figure 3-1-5.

Learning Objective:

Recognize how internal waves may be detected using satellite imagery.

INTERNAL WAVES

Internal waves are a wave phenomena in the ocean that forms between subsurface layers of water of varying density. In the open ocean, internal waves are frequently found along the main thermocline in the layer of strong vertical temperature gradient found below the surface mixed layer.

Internal waves can have a disruptive influence on underwater sound propagation and must be identified, located, and interpreted for effects on naval undersea operations.

Internal waves cannot be directly observed from satellite platforms. However, they can be indirectly detected at the surface in visual imagery. In areas of nearly calm winds and seas and where sunglint patterns are present, distinctive alternate bright and dark bands in the sunglint area indicate the presence of internal waves.

Learning Objective:
Identify methods used to differentiate sea ice from clouds and snow covered terrain as seen in satellite imagery.

SEA ICE

The detection and monitoring of sea ice conditions is of vital importance to ships operating at higher latitudes. Icebergs, calved off ice shelves, and ice floes can pose a danger to ship operations, while the growth and extent of pack ice can impact fleet and support functions. In addition, sonar performance is degraded at the edges of and under ice fields, as sound is scattered and reduced in strength by the ice.

Distinguishing sea ice from clouds or snow-covered terrain is a primary problem in interpreting satellite imagery. In visual imagery, sea ice often has a granular structure, and leads of open water are frequently observed within ice fields. Fields of sea ice are also relatively conservative.

That is, they do not change much from day to day. Clouds, on the other hand, seldom retain the same shape or remain in the same location for more than a few hours. Knowledge of the geography and climatology of a region is most helpful in identifying areas of sea ice.